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Army Alternative Ground Fuels Qualification

PETRO 2012 Conference & Exhibition, National Petroleum Management Association
DOD Alternative Fuels Seminar
31 May 2012

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For PETRO 2012 Conference & Exhibition, National Petroleum Management Association DOD Alternative Fuels Seminar

14. ABSTRACT

Introduction -Tank Automotive Research, Development, and Engineering Center (TARDEC) Mission and Portfolio -Responsibilities as DOD Executive Agent for Ground Fuels & Lubricants Why Alternative Fuels? -Payback -What Army Leaders Are Saying About Energy Alternatives -DoD Strategic Guidance -Army Energy Strategy Army Alternative Ground Fuels Qualification -Bulk Fuel Roadmap -Qualification -Technology Readiness Levels -Identification of Candidate Fuels -Evaluating Candidate Fuels -Candidate Fuels Progressing Through Qualification -Qualification Roadmap -Upcoming Demonstrations of Candidate Alternative Fuels -Completed TARDEC Evaluations -Reports and Papers Available

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Agenda

- Introduction
  - Tank Automotive Research, Development, and Engineering Center (TARDEC) Mission and Portfolio
  - Responsibilities as DOD Executive Agent for Ground Fuels & Lubricants
- Why Alternative Fuels?
  - Payback
  - What Army Leaders Are Saying About Energy Alternatives
  - DoD Strategic Guidance
  - Army Energy Strategy
- Army Alternative Ground Fuels Qualification
  - Bulk Fuel Roadmap
  - Qualification – Technology Readiness Levels
  - Identification of Candidate Fuels
  - Evaluating Candidate Fuels
  - Candidate Fuels Progressing Through Qualification
  - Qualification Roadmap
  - Upcoming Demonstrations of Candidate Alternative Fuels
  - Completed TARDEC Evaluations – Reports and Papers Available

Mission

- Provides full life-cycle engineering support and is provider-of-first-choice for all DOD ground combat and combat support vehicle systems.
- Develops and integrates the right technology solutions to improve Current Force effectiveness and provide superior capabilities for the Future Force.

Ground Systems Integrator for the Department of Defense

Responsible for Research, Development and Engineering Support to *2,800* Army systems and many of the Army's and DOD's Top Joint Warfighter Development Programs

Portfolio

Combat Vehicles

- Heavy Brigade Combat Teams
- Strykers
- MRAPs
- Ground Combat Vehicles (Future)

Force Projection

- Fuel & Water Distribution
- Force Sustainment
- Construction Equipment
- Bridging
- Assured Mobility Systems

Tactical Vehicles

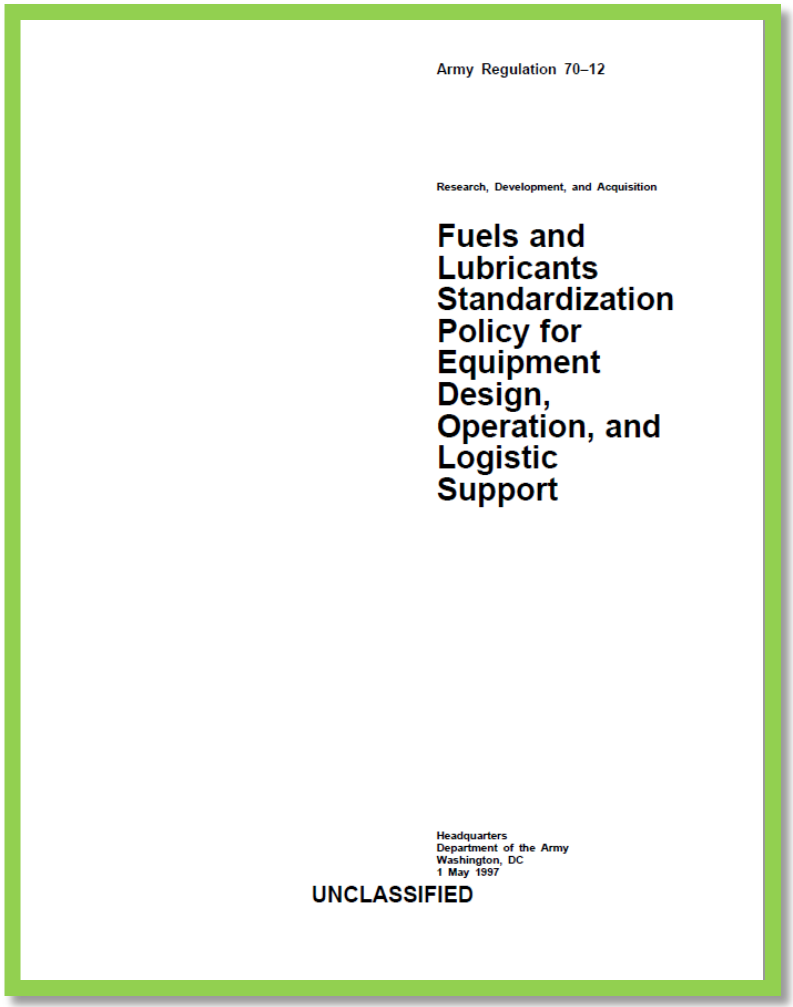
- HMMWVs
- Trailers
- Heavy, Medium and Light Tactical Vehicles

Robotics

- Technology Components
- Demonstrators
- Military Relevant Test & Experimentation
- Transition & Requirements Development

TARDEC Engineers Provide Cradle-To-Grave Engineering Support

Responsibilities as DOD Executive Agent for Ground Fuels & Lubricants



Army Regulation 70–12

Research, Development, and Acquisition

Fuels and Lubricants Standardization Policy for Equipment Design, Operation, and Logistic Support

Headquarters
Department of the Army
Washington, DC
1 May 1997

UNCLASSIFIED

AR 70-12

"The Director of the U.S. Army **TARDEC… will execute the RDTE program** for fuels and lubricants as the DOD Executive Agent for ground fuels and lubricants. **TARDEC is also the single point within the DA for control of all petroleum and petroleum related specification commodities** assigned to the Army and DOD and for Army representation to NATO and ABCA forums related to ground fuels and lubricants."

ARMY F&L MISSION FOR GROUND SYSTEMS IS A TARDEC RESPONSIBILITY

Energy Security

"Clearly, future operations will depend on our ability to . . . use more renewable or alternative sources of energy."

The Honorable John McHugh, Secretary of the Army[1]

- **More options, less risk**
  - Military acceptance to use more diverse (non-petroleum) fuels
  - Ensure Army operations are not adversely affected by fuel-equipment incompatibilities
  - Addresses growing challenges to energy supply – promotes long-term energy surety
- **Important to national security**
  - "In long term, alternative fuels have the potential to be an important part of the Nation's energy landscape"[2]

[1]2012 Budget Request for the Army, testimony before the House Armed Services Committee, 2 March 2011
[2]DOD Energy for the Warfighter: Operational Energy Strategy

Energy Alternatives – What Army Leaders Are Saying

Quotes from ARMY AL&T, Jan-Mar 2012:

Richard G. Kidd IV, Deputy Assistant Secretary of the Army for Energy and Sustainability (at AUSA, October 2011):

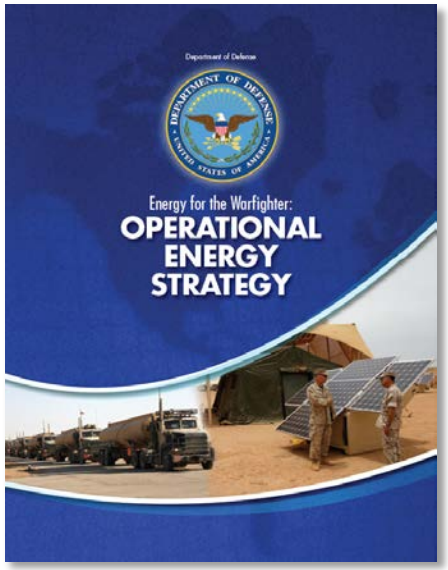
"[There] is a commitment from the Army's senior most leadership to make energy security a priority. It's fiscally responsible, operationally necessary, and mission-critical."

LTG Raymond V. Mason, Deputy Chief of Staff of the Army, G-4 (Logistics):

"One of the issues is, does operational energy just include the battlespace and what's deployed? Or does it include things back in the generating space, the institutional Army?"

The latter is true, he said. "For example, actions that occur at the National Training Center or the Joint Readiness Training Center [that] prepare units to deploy [are] part of operational energy."

DOD Strategic Guidance for Alternative Fuels

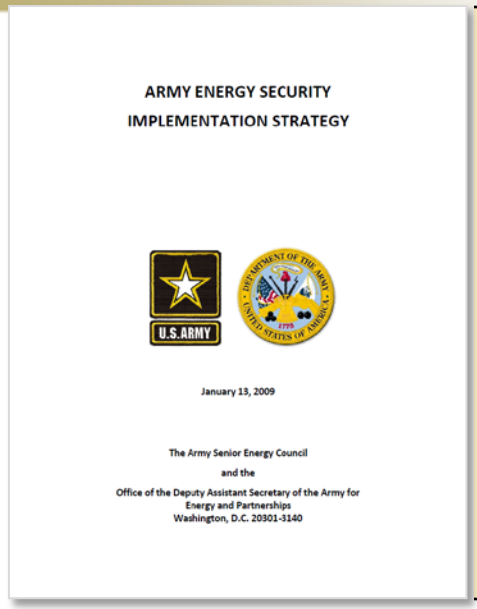


From the DOD Operational Energy Strategy, May 2011:

The Department also is taking steps to promote long-term surety of supply. The volatility of oil prices will continue to be a budgetary challenge for the Department, and the realities of global oil markets mean a disruption of oil supplies is plausible and increasingly likely in the coming decades. The Services have already taken steps to certify aircraft, ships, tactical vehicles, and support equipment to use alternative liquid fuels, a prudent insurance policy against future oil supply disruptions and high prices.

Although the Department currently procures alternative fuels at a premium for testing purposes, the Department will acquire such fuels for military operations at prices that are competitive with the market price for conventional fuels. The Department also may acquire alternative fuels to meet a mission imperative.

Army Energy Strategy Plan (Fuels Related)



ARMY ENERGY SECURITY
IMPLEMENTATION STRATEGY

U.S.ARMY

January 13, 2009

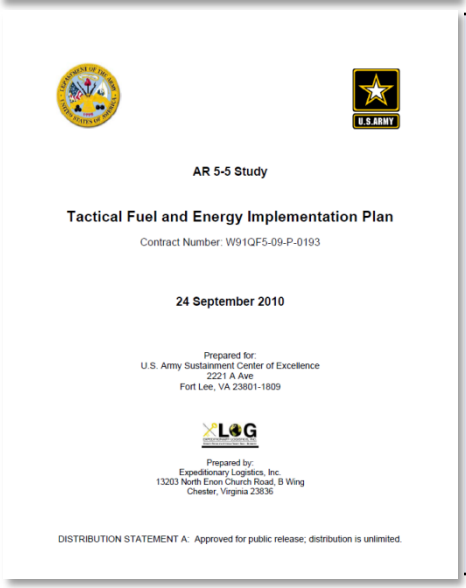
The Army Senior Energy Council
and the
Office of the Deputy Assistant Secretary of the Army for
Energy and Partnerships
Washington, D.C. 20301-3140

Strategic Energy Security Goal 3

Increased Use of Renewable / Alternative Energy

Objective 3.3

Transition from fossil fuel based tactical mobility/power generation to renewable and alternative energy/sources.



U.S.ARMY

AR 5-5 Study

Tactical Fuel and Energy Implementation Plan

Contract Number: W91QF5-09-P-0193

24 September 2010

Prepared for:
U.S. Army Sustainment Center of Excellence
2221 A Ave
Fort Lee, VA 23801-1809

Prepared by:
Expeditionary Logistics, Inc.
13203 North Enon Church Road, B Wing
Chester, Virginia 23836

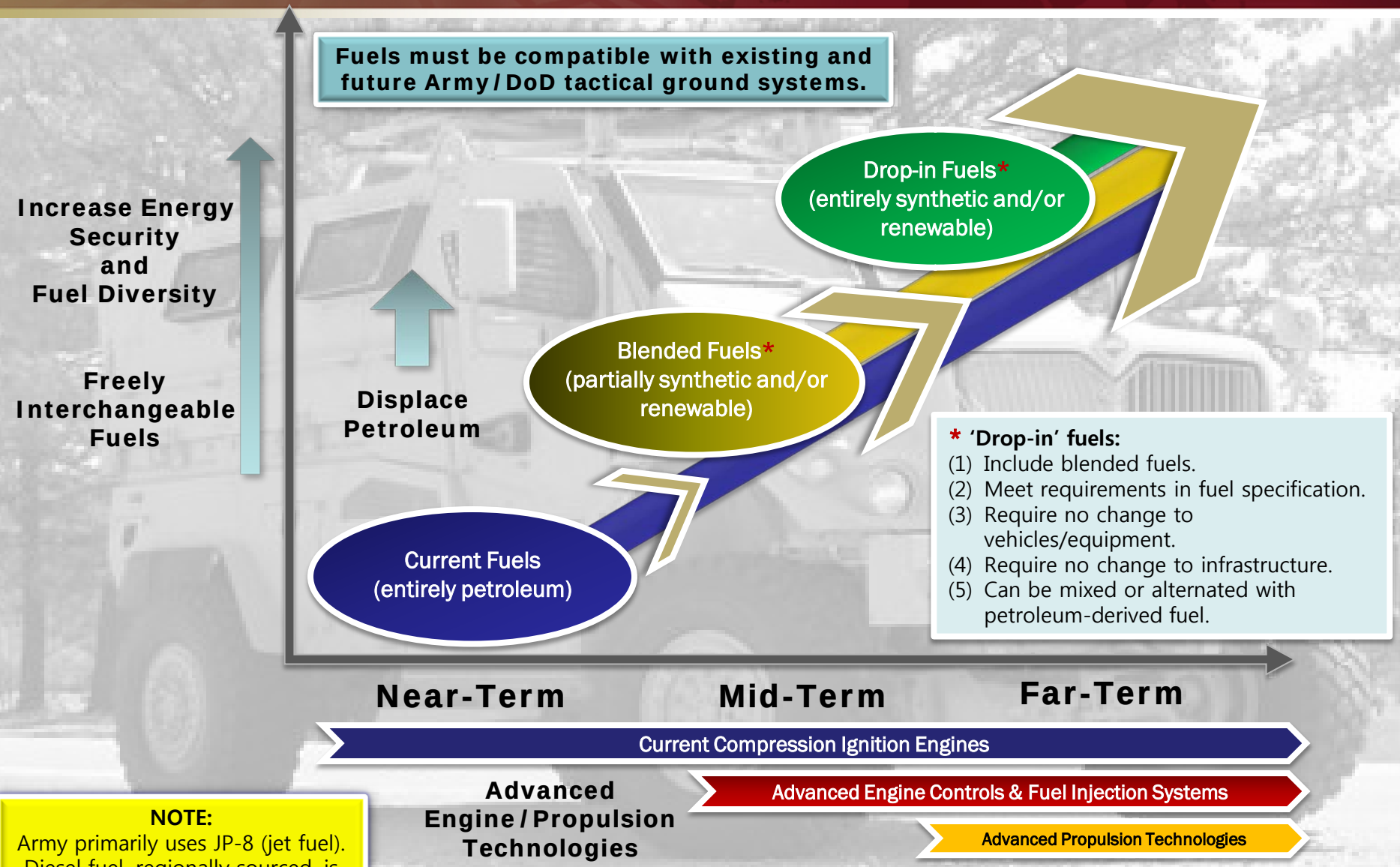
DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

Implementation Plan per AR 5-5 Study:

By 2028, 50% of the fuel requirement in the training base for the tactical mobility fleet (surface and air) is met by alternative fuel blends.

- Intended outcomes focused on integrating the use of alternative fuels in vehicle and aircraft engines in the training base
- Percent of fuel requirement met by alternative fuel blends:
  - 15% by FY18
  - 30% by FY23
  - 50% by FY28

Army Bulk Fuel Roadmap



NOTE:
Army primarily uses JP-8 (jet fuel). Diesel fuel, regionally sourced, is likely alternate if JP-8 is not available or accessible.

Alternative Fuels Qualification Technology Readiness Levels

Only a partial representation of TRL tests and evaluations.

Develop data needed to assess fuel's suitability for use.

Build user knowledge of and confidence in use of fuel.

Laboratory Evaluations

- TRL 1: Basic Fuel Properties
  - Distillation
  - Hydrocarbon Range
  - Density
- TRL 2: JP-8 Fuel Specification Properties
  - Oxidative Stability
  - Cetane Index (Report Only)
- TRL 3: Fit for Purpose
  - Storage Stability
  - Material Compatibility
  - Viscosity vs. Temperature
- TRL 4: Extended Lab Fuel Property Test
  - Dermal Irritation Test
  - Cetane No. / Derived Cetane No.

Component Evaluations

- TRL 5: Component Rig
  - Fuel Injection System Testing (Rotary, Inline, Common Rail, Unit Injectors)
- TRL 6: Engine Testing
  - NATO 400-hr test protocol, modified to desert-like conditions
  - 210-hr TWV test cycle

System Evaluations

- TRL 7: Limited Ground Vehicle/Equipment Demos
  - Vehicle Test Track Evaluation
  - Tactical Gen Set Side-by-Side Operability Evaluation
  - TWV Pilot Field Demo
  - Force Projection Equipment Pilot Field Demo

Qualification Report

- Executive Summary of RDT&E to PEOs-PMs
- Independent Third Party Review

Demonstrations

AS REQUIRED

- TRL 8: Validation
  - Ground Equipment Evaluations – Proving Grounds
- TRL 9: Field Service Evaluations
  - Ground Equipment Evaluations (typically long duration, at CONUS field locations, wide-in-scope)

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Identification of Candidate Alternative Ground Fuels

EMERGING
ALTERNATIVE FUELS MARKET

- **DOD**
- **DOE**
- **Industry**
- **Academia**
- **Fuel Producers**
- **Equipment OEMs**
- **Other Government Agencies**
- **Standards Development Organizations**

Market Connection

- Manufacturing technology
- Fuel data, samples
- Market drivers

Candidate drop-in alternative fuels for qualification

Evaluating Candidate Alternative Ground Fuels

Candidate drop-in alternative fuels

Fuel / Component Evaluations

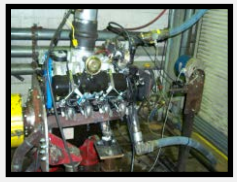
- Chemical composition
- Physical properties
- Component performance / durability

Example:

Poor lubricity fuel may cause increased wear rates in fuel injectors and injection pumps.

Example:

Poor long-term storage stability fuel characteristics could impact readiness.



Engine Evaluations

- Fuel ignitability
- Fuel combustion
- Performance / durability

System Evaluations

- Operability
- Performance
- Demonstrations

Example:

Low cetane-rated fuel may cause difficult cold-starts and combustion instability.

Example:

Low fuel viscosity may lead to internal fuel pump leaks resulting in reduced power.

Approval and acceptability of alternative fuels for use in military ground equipment.

Candidate Fuels Progressing Through Qualification

- Two alternative fuels for which evaluations are being completed to assess their impacts on tactical ground systems
  - Blends of JP-8 and up to 50% by volume of Synthetic Paraffinic Kerosene (SPK)
    - Fischer-Tropsch Synthetic Paraffinic Kerosene (FT SPK)
    - Hydroprocessed Esters and Fatty Acids (HEFA SPK)
  - Both products (FT SPK and HEFA SPK) are very similar compositionally
    - Resultant properties are very similar
    - Evaluations thus conducted using one of these blends will be representative of evaluations for the other by similarity
- Evaluations are conducted using nominal 50%:50% volumetric blends
- Blends are meant to be "drop-in" fuels
    - Meets fuel performance requirements (in spec)
    - Requires no change to vehicles/equipment
    - Requires no change to infrastructure
    - Can be mixed or alternated with petroleum-derived fuel

Qualification Roadmap for FT SPK and HEFA SPK Blends (Tactical/Combat Ground Equipment)

RDT&E Description	Pre-FY09	FY09	FY10	FY11	FY12	FY13	FY14
TRL 1 - 4:							
Basic Fuel Properties and Composition	FT SPK	HRJ					
Fuel Specification Properties	FT SPK	HRJ					
Fit for Purpose Testing	FT SPK	HRJ					
Extended Property Testing	FT SPK	HRJ					
TRL 5:							
Fuel System 1	Amb T		Elev T				
Fuel System 2			Elev T				
Fuel System 3			Elev T				
Fuel System 4			Elev T				
TRL 6 - Subsystems:							
Engine 1	E1*	E3		E3			
Engine 2	E2	E3	E4				
Engine 3			E3				
Engine 4		E3					
Engine 5				E3			
Engine 7				E3			
Engine 8			E2				
TRL 7 - Systems:							
10-kW Tactical Gen Sets	G1						
HMMWV Test Track Evaluation							
Ground Vehicle Pilot Field Demos		TWVs			Tactical/Combat Vehicle		
FPT Equipment Pilot Field Demo							
Tactical Gen Sets –							
2-kW, 3-kW, 10-kW, 15-kW			G2		G3		
30-kW, 100-kW				G2	G3		

FINAL QUALIFICATION REPORT

Engine Tests Key	
E1	Performance & Emissions
E2	210-hr TWV Test Cycle
E3	400-hr NATO Test Cycle
E4	Cetane Window Evaluation

Gen Set Tests Key	
G1	Performance & Operability
G2	1500-hr Reliability
G3	Electrical Performance

* Non-Turbo engine variant

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Upcoming Demonstrations of Candidate Alternative Fuels

- Camp Grayling Demo
  - Camp Grayling, located in central northern Michigan, is the nation's largest National Guard training site
  - Selected Michigan Army National Guard units will operate a variety of tactical/combat ground vehicles on a biofuel during their training exercises
  - Taking place in June 2012, total of 10,000 gals of alternative fuel
- Fuel and Water Distribution Systems Demo
  - Will demonstrate pump-engine capabilities (fuel and water), and the Aviation Forward Area Refueling System (AAFARS), while operating on alternative fuel
  - Pump-engine recirculation loop on water, engines on alternative fuel – 400 hrs
  - AAFARS recirculation loop and engine on alternative fuel – 400 hrs at 90°F+
  - Demo starts in summer 2012, Southwest Research Institute campus in Texas
- Green Warrior Convoy
  - In Spring 2013, convoy will demonstrate vehicle energy and educate the value of S&T in Army vehicles; to include operation on alternative fuel
  - Vehicles will travel from Warren, Michigan to Washington D.C. as part of the road testing of technologies and systems developed at TARDEC

NOTE: Alternative fuel for these demos is HEFA SPK/JP-8 blend

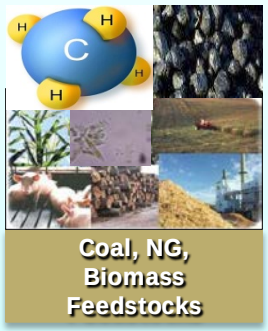
Completed TARDEC Evaluations Reports and Papers Available

ID #	Document Title	Publication Date	Publication Reference	
			DTIC	Other
1	Synthetic Fuel Lubricity Evaluations	Sep-03	ADA421822	Interim Report TFLRF No. 367
2	Synthetic JP-5 Aviation Turbine Fuel Elastomer Compatibility	Nov-03	ADA477802	TARDEC Report No. 13978
3	Exhaust Emissions From a 6.5L Diesel Engine Using Synthetic Fuel and Low-Sulfur Diesel Fuel	Dec-03	ADA426513	Interim Report TFLRF No. 370
4	Alternative Fuels: Assessment of Fischer-Tropsch Fuel for Military Use in 6.5L Diesel Engine	Jan-04	--	SAE Paper No. 2004-01-2961
5	Evaluation of Ball on Three Disks as Lubricity Evaluator for CI/LI in Synthetic JP-5	Apr-04	ADA462280	TARDEC Report No. 13977
6	Synthetic Fischer-Tropsch (FT) JP-5/JP-8 Aviation Turbine Fuel Elastomer Compatibility	Feb-05	ADA477802	TARDEC Report No. 15043
7	Bench Top Lubricity Evaluator Correlation with Military Rotary Fuel Injection Pump Test Rig	Oct-05	ADA524925	SAE Paper No. 2005-01-3899
8	Properties of Fischer-Tropsch (FT) Blends for Use in Military Equipment	Apr-06	ADA521910	SAE Paper No. 2006-01-0702
9	Elastomer Impact When Switch-Loading Synthetic Fuel Blends and Petroleum Fuels	Jul-06	ADA459513	TARDEC Report No. 16028
10	The Effect of Switch-Loading Fuels on Fuel-Wetted Elastomers	Jan-07	ADA497968	SAE Paper No. 2007-01-1453
11	Evaluation of Synthetic Fuel for Army Ground Applications, Tasks II-VI	Jun-11	TBD	Interim Report TFLRF No. 389
12	Evaluation of Synthetic Fuel in Military Tactical Generators	Jun-08	ADA482914	Interim Report TFLRF No. 392
13	Engine Durability Evaluation Using Synthetic Fuel, Caterpillar C7 Engine	Oct-08	ADA494498	Interim Report TFLRF No. 391
14	Fischer-Tropsch Synthetic Fuel Evaluations: HMMWV Test Track Evaluation	Sep-09	ADA509165	Interim Report TFLRF No. 400
15	Evaluation of the Fuel Effects of Synthetic JP-8 Blends on the 6.5L Turbo Diesel V8 from General Engine Products (GEP) Using the NATO Standard Engine Laboratory Test AEP-5, Edition 3, May 1988	Dec-09	--	TARDEC Report, Distr A
16	Durability Evaluation of Two New Production Caterpillar C7 Engines Subjected to Elevated Temperature 400 Hour NATO Tests Fueled by JP-8 and 50%/50% Blend of JP-8 and S-8	Feb-10	--	TARDEC Report, Distr E
17	Synthetic Fuel Blend Demonstration Program at Fort Bliss, Texas	May-10	ADA533890	Interim Report TFLRF No. 407
18	Lubricity and Derived Cetane Number Measurements of Jet Fuels, Alternative Fuels and Fuel Blends	Jul-10	ADA529442	Interim Report TFLRF No. 405
19	Cummins V903 Alternative Fuel Evaluation, NATO Modified Standard Laboratory Test AEP-5	May-11	ADB369316	TARDEC Report, Distr D
20	Military Fuel and Alternative Fuel Effects on a Modern Diesel Engine Employing A Fuel-Lubricated High Pressure Common Rail Fuel Injection System	Aug-11	ADA547468	GVSETS 2011 Paper, Distr A
22	Evaluation of Military Fuels Using a Ford 6.7L Powerstroke Diesel Engine	Aug-11	TBD	Interim Report TFLRF No. 415
21	Durability Evaluation of the Effects of Fischer-Tropsch Derived Synthetic Paraffinic Kerosene Blended Up to 50% With Petroleum JP-8 on a Detroit Diesel/MTU 8V92TA Engine	Dec-11	ADA555387	TARDEC Report, Distr A

Back-up Slides

FT SPK and HEFA SPK Blendstocks – How They Are Made

CTL / GTL / BTL / CBTL: All use Fischer-Tropsch Processes



Syngas manufacture

O_2 / Air

Syngas $CO + 2H_2$

Fischer-Tropsch Synthesis

H_2O

Paraffins

Selective Hydrocracking

Product Separation

FT SPK

Very similar processes also used in traditional petroleum JP-8 Production

Biomass Feedstock (renewables)

Deoxygenation & Hydrotreating

H_2O
CO_2

Paraffins

Selective Hydrocracking

Product Separation

HEFA SPK

Because of the similar end-processing, FT SPK and HEFA are chemically similar blendstocks

More Possibilities For Making Alternative Jet Fuels (or Blendstocks)

Used with permission from Mark Rumizen, FAA

Synthetic Biology

Genetically Engineered Microbes

Fermentation

Jet Fuel-Like Product

Sugar

Alcohol Oligomerization

Fermentation

Dehydration

Olefins

Conventional Refinery Processes

Polymerization

Lignocellulose

Pyrolysis

Pyrolysis

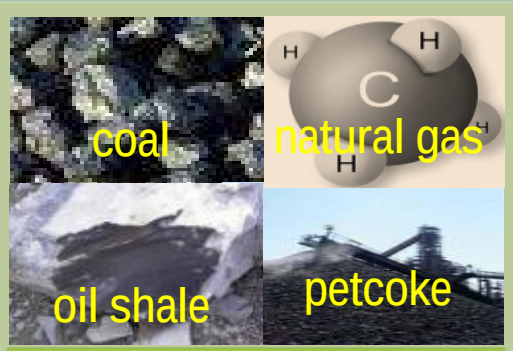
Bio-Crude

Hydroprocessing

Jet Fuel-Like Product

Alternatively Sourced Liquid Hydrocarbons

Biomass Feedstock (renewables)



Fossil Energy Feedstock (large U.S. resource)

Petroleum Crude Oil

(increasingly difficult discovery and unfriendly-nation production)

- Various conversion processes dependent on feedstock
- Product meeting commercial and/or military specifications
- Specs evolving to address alternatively sourced hydrocarbons

Jet Fuel

- ASTM D1655: conventional jet fuel
- ASTM D7566: blends of synthetic kerosene with conv. jet fuel
- MIL-DTL-83133: JP-8, also blends of synthetic kerosene with JP-8

Diesel Fuel

- ASTM D975: up to 5% v. FAME biodiesel (B100) allowed in diesel fuel
- ASTM D6751: B100 spec
- ASTM D7467: blends of 6%-20% v. FAME biodiesel (B100) with diesel